FINNISH METEOROLOGICAL INSTITUTE

Utilization of coastal radars for monitoring sea ice drift and deformations

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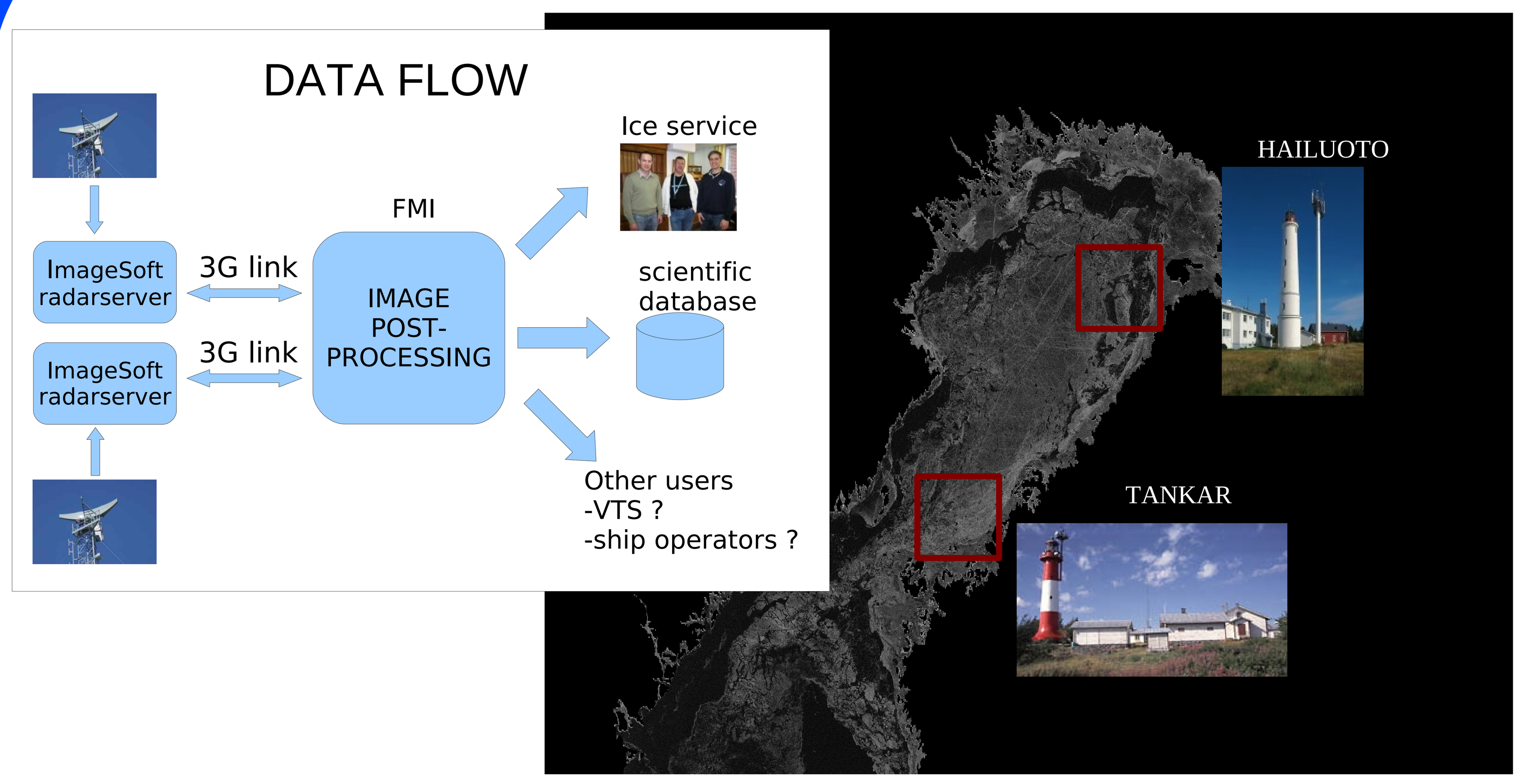
BACKGROUND

One of unresolved question of sea ice physics is a relationship between the large scale ice motion and local ice drift and deformations. In a large scale, ice drift reflects atmospheric and oceanic circulation patterns. However, in a local scale the temporal and spatial patterns of ice motion can be rather different from the scales of the driving forces. This is because the local scale motion depends very much on the small scale features like, cracks, leads and ice floes, as well as on local ice thickness distribution.

In addition to the ice buoys, ice drift can be determined by analysis displacement of ice field from any pair of images. For this purposes,the synthetic apparature radar (SAR) satellite data is the most powerful instruments, since the horizontal resolution of satellite SAR datais from 20 - 250 meters with a spatial coverage of few hundred kilometers. Deficiency of the SAR derived ice motion fields is the rather long interval between two images. Very seldom the interval between two images is less than a day. In order to obtain data of local ice dynamics in high temporal and spatial scale, we utilize ship and coastal radar instruments for our research.

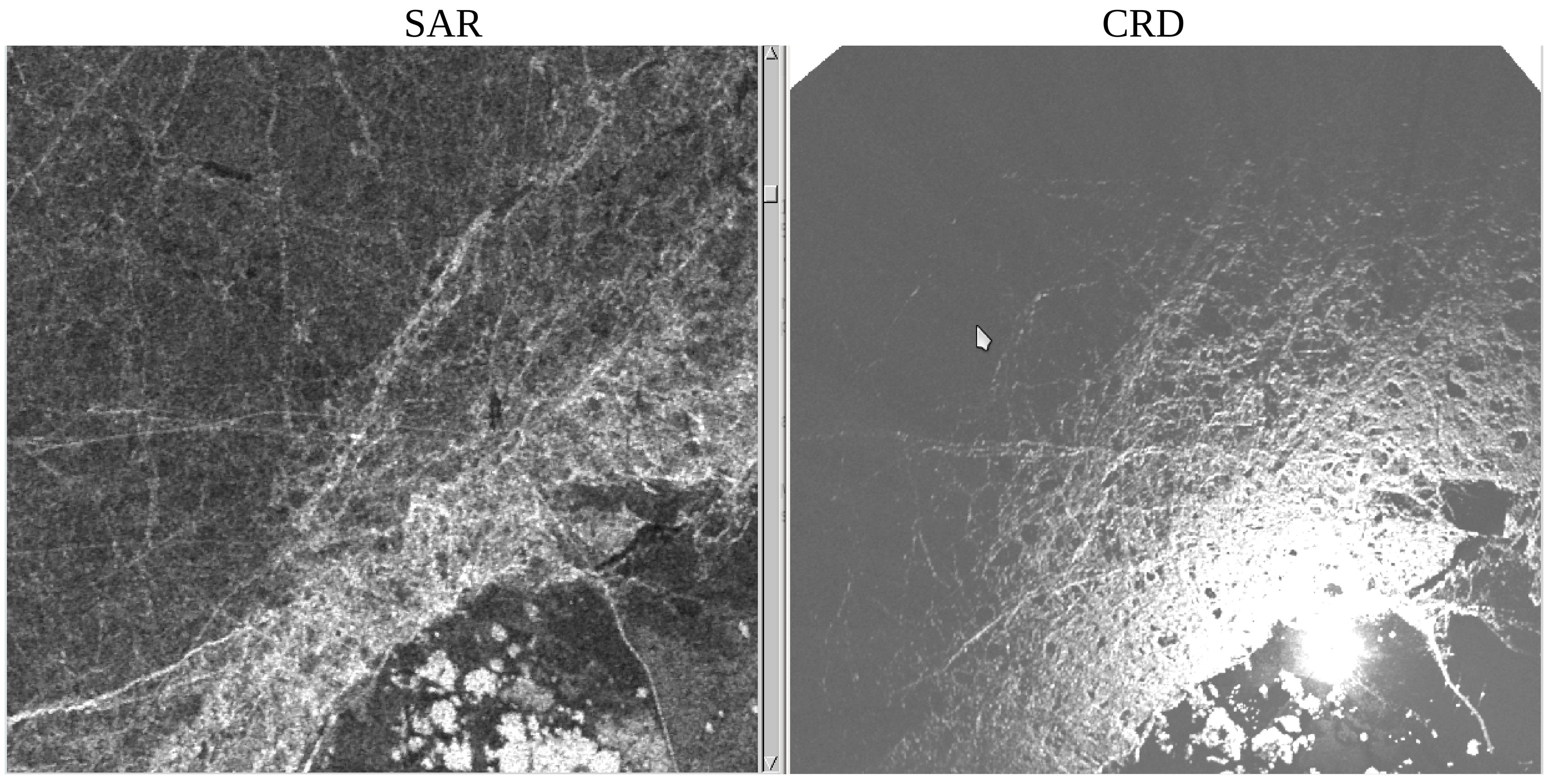
Ice information retrieved from the the coastal radars is also highly important for real time ice monitoring and tactical navigation. After the pilot projects on 2009 and 2010, the FMI established a permanent monitoring system enabling a real time data flow from a two radar stations in the Bay of Bothnia.

RADAR STATIONS IN THE BAY OF BOTHNIA



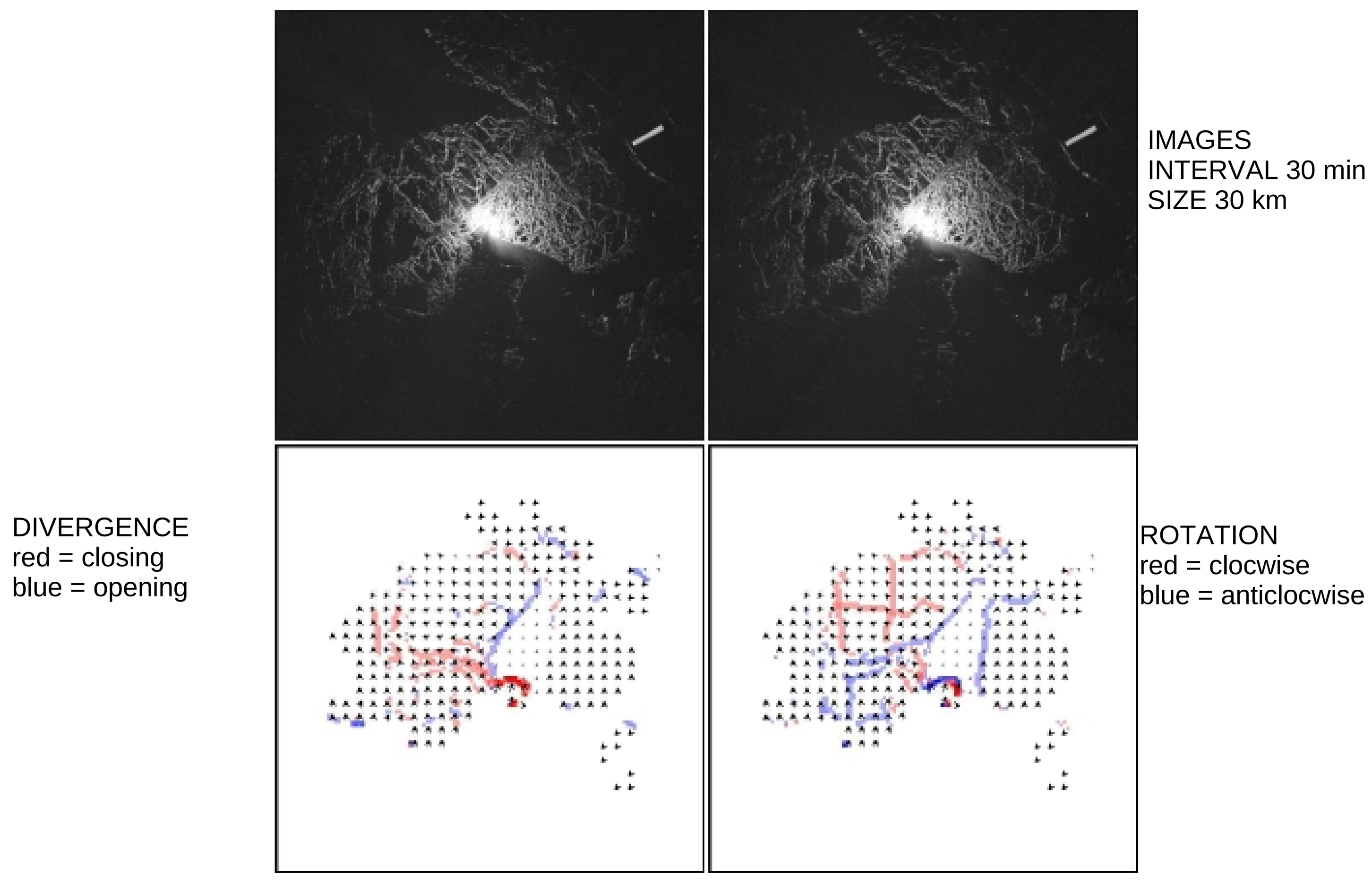
The two radar stations have Terma 9 Ghz X-band radars with 30.2 and 37.8 m antenna heights. An independent radar server captures and processes the radar image without interfering the normal use of the radar. The images are then sent via 3G link to FMI headquater for a postprocessing and further dissemenation.

SATELLITE SAR VS. COASTAL RADAR DATA



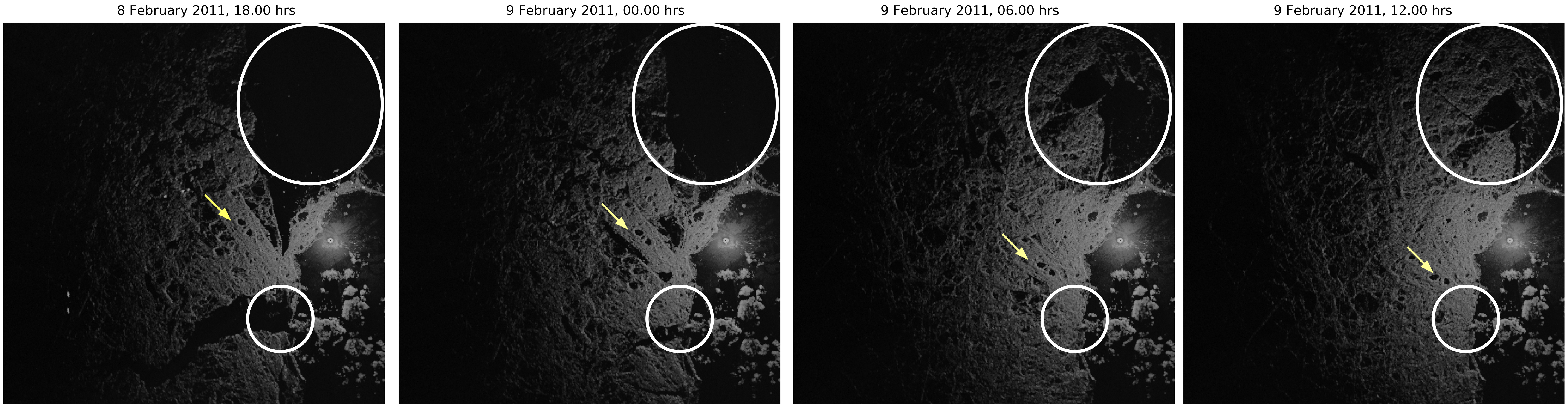
Radar backscattering depends strongly on the ice type. Deformed ice and ridges give strong backscattering while weak signals are from open water or level ice. Satellite and coastal radars are rather similar in terms of operation principle and the main difference is in incidence angle. The ship and coastal radars are developed for the detection of targets and echoes from ice and waves are considered noise sough to be filtered out, but our system can independently be set to digitize precisely these signals in an optimal way.

KINEMATIC PARAMETERS



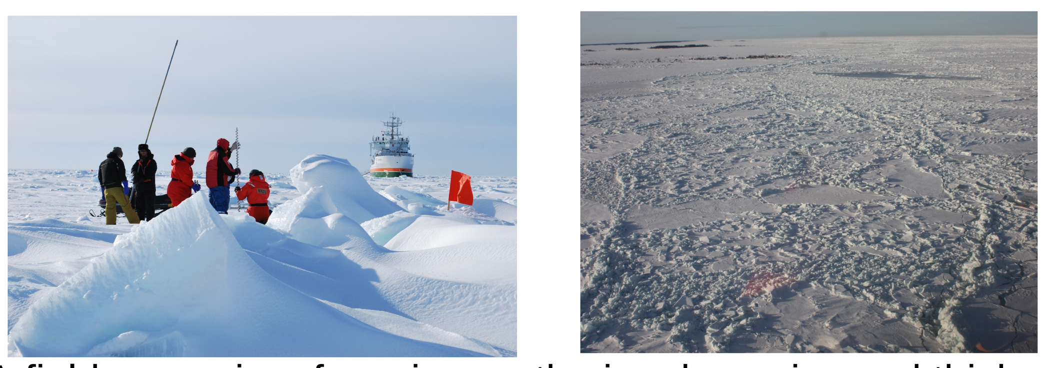
The ice motion detection from radar image pairs is based on a phase correlation approach. This example is based on the ship radar data digitizing system installed to the I/B Otso. The shipboard application is especially fruitful when used during ice research cruises as the strain fields at the field sites can be resolved.

ICE DEFORMATION EVENTS



The above images are snapshots (6h intervals) of an episode where the coastal ice fields off the Tankar lighthouse are experincing compacting, shearing and ridging. At that time, the Bay of Bothnia was entirely ice covered and level ice types, showing as uniform black in the images, were still abundant. Northerly winds of about 14 m/s induced ice drift that manifested as shearing and compressive deformations against the coast and as reduction of level ice concentration. An ice covered lead is seen to close (images 1-2) after which the level ice in the upper right starts to deform (images 2-4). The arrow pinpoints a selected tractable feature and ships are seen in the first image as well.

The radar images are captured once per revolution, about 20 images per minute, which enables very detailed tracking of the deformation characteristics. A basic visualisation tool is an animated sequence, which in the present case reveals an intricate pattern of local deformations. The ice cover is seen to move as a set of coherent aggregates, or floelike units that deform trough shearing and compression along their boundaries. Large velocity gradients are observed and the drift speed and directions could differ considerably from the average drift pattern .



A field campaign, focusing on the ice dynamics and thickness distribution was conducting in the region on February-March 2011. Measurement include ice drift and stress measurements, em-ice thickness measurements and ULS ice thickness monitoring.